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Before the
Federal Communications Commission
Washington DC 20554

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In the Matter of	)	
	)	
Revision of Part 15 of the Commission's Rules	)	ET Docket 98-153
Regarding Ultra-Wideband Transmission	)	DA 01-753
Systems	)	

Comments of XtremeSpectrum, Inc. On UWB/PCS Interference Issues

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XtremeSpectrum, Inc. hereby files these Comments in response to Public Notice DA 01-753 in the above-captioned proceeding.[1] Specifically, this document comments on the Qualcomm Report discussing potential interference from UWB transmitters into PCS wireless phones.[2] In a companion filing, also submitted today, XtremeSpectrum responds to four studies investigating UWB interference into GPS receivers.

IMPORTANT: The attached *XtremeSpectrum, Inc. Technical Statement on Reports Addressing Potential PCS Interference from UWB Transmitters* is not an appendix, but an integral part of these Comments.

XtremeSpectrum conducts research on ultra-wideband communications systems, and intends to become a manufacturer once the Commission authorizes certification of such systems. XtremeSpectrum takes no position on ultra-wideband radar applications.

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1 *Comments Requested on Reports Addressing Potential Interference from Ultra-Wideband Transmission Systems*, DA 01-753, in ET Docket No. 98-153 (released March 26, 2001).

2 *Report of Qualcomm Incorporated* (filed March 5, 2001) (Qualcomm Report).

A. Summary.

Qualcomm's analysis makes three unrealistic assumptions: free-space propagation indoors; emission limits 12dB above those the Commission proposed; and an unrealistic interference threshold. Correcting just these assumptions reduces the predicted interference distance between UWB and PCS to less than 2 meters.

Qualcomm's laboratory studies of UWB interference provided direct indication of the interference threshold due to UWB emissions, but the analysis was not adjusted accordingly. When the results are corrected to reflect the measured threshold, the interference distance again drops to less than 2 meters.

B. Qualcomm's Analysis Systematically Overstates the Potential for UWB Interference into GPS.

The analytical studies in the Qualcomm Report overestimate the interference from UWB transmitters into GPS phones.

1. Qualcomm incorrectly assumes free-space propagation for indoor operation.

XtremeSpectrum has proposed that UWB communications be limited to indoor operations.[3] Interference from such systems to outdoor PCS phones is unlikely, owing to the high attenuation across exterior building walls. The PCS community is concerned, however, about indoor-to-indoor UWB interference into PCS phones.[4]

In its analysis of UWB interference, however, Qualcomm assumes free-space propagation, which greatly overestimates the signal strength indoors. A better propagation estimate, based on a widely accepted study by Bultitude *et al.*, shows a 12dB

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[3] Comments of XtremeSpectrum, Inc. at 11 (filed Sept. 12, 2000).

[4] *E.g.*, Letter from Charles W. McKee, Sprint PCS to Bruce A. Franca, FCC at 4 (filed Feb. 21, 2001).

loss, relative to free space, over a 10m range in a typical indoor environment.[5] This alone reduces minimum the separation under Qualcomm's criteria to less than 9 meters. (Further reductions are discussed below.)

2. Qualcomm ignores 12dB of protection margin in the Commission's proposed emission limits.

Qualcomm's analysis is based on UWB emission limits of 500uV/m at 3m.[6] The Commission, however, proposed lowering those emission limits by 12dB in the PCS band.[7] XtremeSpectrum has endorsed the lower limit.[8] When this 12dB of added protection is factored in, the minimum separation drops to 3 meters.[9]

Qualcomm's data agrees. When its plot on page 11 (figure 3.4) is recalculated using UWB emission levels 12dB lower, with other factors unchanged, the separation distance becomes only 3 meters. Note that this result is still an overestimate, because it assumes an unrealistic interference threshold.

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5 Robert J.C. Bultitude, Samy Mahoud, and William Sullivan, *A Comparison of Indoor Radio Propagation Characteristics at 910 MHz and 1.75 GHz*, 7 IEEE Journal on Selected Areas in Communications No. 1 at 20 (Jan. 1989).

6 Qualcomm Report at 2. *See* 47 C.F.R. Sec. 15.209(a).

7 *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, 15 FCC Rcd 12086 at para. 39 (2000) (Notice).

8 Reply Comments of XtremeSpectrum, Inc. at 4 (filed Oct. 27, 2000)

9 This correction uses a reduced indoor-environment attenuation of 9dB, rather than 12dB as above, to account for the shorter range at reduced emission levels.

3. Qualcomm assumes a perfectly quiet radio environment.

All of Qualcomm's calculations set the interference threshold from UWB devices at 6dB *below the thermal noise floor.*[10] This effectively assumes a complete absence of other radio sources in the band. However, because Qualcomm's concerns about UWB make sense only for indoor PCS operation, multi-path interference is inevitable, and will raise the noise floor. So will interference from other PCS base station signals. Even if we assume only a 4dB allowance due to interference from such sources -- still 2dB *below the noise floor* -- the minimum separation UWB-PCS separation becomes less than 2 meters.

CONCLUSION

The Qualcomm Report establishes that a UWB transmitter may interfere with PCS phones if it propagates indoors as in free space, emits at 12dB over the proposed limit, and operates with an unrealistic interference threshold.

Corrections to Qualcomm's results are needed to account for propagation in an indoor environment, reduced emission limits below 2GHz, and realistic interference threshold levels. Taken together, these corrections show UWB will not interfere with PCS beyond 2 meters.

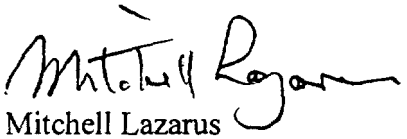
In short, rules that conform to the Notice will adequately protect PCS from UWB interference.

In a companion filing today, XtremeSpectrum shows that adjustments to the proposed emission mask, measurement bandwidth, and peak-to-average measurement techniques (none affecting the PCS band) are needed to address issues of interference to

GPS.[11] Comments on these issues were specifically invited in the Notice,[12] and XtremeSpectrum's suggestions are well within the scope of the Notice. Even if not among the options expressly outlined in the Notice, they are certainly a logical outgrowth of the questions raised.[13]

The Commission can move expeditiously to adopt rules that authorize UWB devices, without fear of harmful interference into either PCS or GPS.

Respectfully submitted,



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10 Qualcomm Report at 7.

11 *See Comments of XtremeSpectrum, Inc. on Issues of Interference Into Global Positioning System Receivers* (filed April 25, 2001).

12 See Notice at paras. 36-37 (spectral lines), 39 (emission mask), 43-44 (peak-to-average measurement), 50 (measurement resolution bandwidth).

13 *See* Omnipoint Corp. v. FCC, 78 F.3d 620 631 (D.C. Cir. 1996) (second round of comment not required where final rule is "logical outgrowth" of proposed rule), *citing* American Water Works Ass'n. v. EPA, 40 F.3d 1266, 1274 (D.C. Cir. 1994).

XtremeSpectrum, Inc. Technical Statement on Reports Addressing Potential PCS Interference from UWB Transmitters

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April 25, 2001

Table of Contents

1. Introduction

These comments are submitted in response to a report submitted by QUALCOMM concerning the anticipated effects of UWB devices on personal communications system (PCS) receivers.

In their comments, QUALCOMM expresses concerns that PCS receivers in proximity to UWB devices that might operate under Part 15 rules would cause harmful interference. They present analysis and test results that purport to show that large separation distances will be required between UWB devices and PCS handsets to prevent such interference. QUALCOMM also expresses concern that UWB devices might interfere with any GPS-based E-911 services that might be offered in conjunction with PCS service, although they present no analysis or testing to validate such concerns about GPS in their comments.

In these comments we address the QUALCOMM's concerns by performing some additional analysis to show that UWB interference to PCS receivers is unlikely in any kind of realistic situation. As a result, the likely effects on the PCS system as a whole are negligible.

Our comments will demonstrate that in the analyses and tests presented by QUALCOMM there are several specific points that lead to unrealistic results:

1. The original analysis assumes that the 1.9 GHz PCS band will be a *primary band* for UWB operation. Actually, both XtremeSpectrum and the FCC have proposed that emissions in this band only be permitted at levels 12 dB below Part 15 general emission limits for communications systems.

2. Much of the original analysis is based on free-space propagation losses, with no account for non-line-of-sight effects. More realistic models demonstrate significantly lower interference potential.

3. The original analysis assumes a very conservative value for the threshold of harmful interference due to UWB emissions (6 dB below the thermal noise floor). Both the analytical expressions and laboratory results presented by QUALCOMM show that this threshold is too conservative, and a more realistic level removes any concern for harmful interference.

When the analyses and test measurements presented by QUALCOMM are re-examined in light of these specific points, the resulting conclusion is that there is very little reason for concern that UWB operations will lead to harmful interference to PCS.

2. Concerns expressed by QUALCOMM are eliminated through the use of more realistic assumptions and analyses

In this section, we will re-examine the specific analytical and laboratory results presented by QUALCOMM. We will show that application of realistic models and assumptions eliminates any potential for harmful interference.

2.1 Background information on CDMA and PCS provided in the comments

Before we discuss the analysis of the generic PCS receiver considered in the original comments, it is helpful to reproduce an equation given that is used to measure the performance of CDMA systems:

$$\frac{E_b}{N_0} = \frac{\eta P_0}{N_{th} + U + P_{mp} + \sum_i P_i} P_g$$

This equation provided by QUALCOMM shows that in a CDMA system (such as CDMA PCS), the measurement of performance depends on the ratio of bit energy to noise power density. The relevant components of the noise power term are thermal noise (N_{th}), assumed UWB interference (U), channel noise due to multipath (P_{mp}), and interference from multiple other cells (ΣP_i). In spite of this fact, the analysis in the comments is based on the assumption that harmful interference will result whenever the UWB emissions seen by the receiver lead to a 1 dB rise in the thermal noise floor (i.e. when UWB power exceeded a level 6 dB below the receiver thermal noise floor). The reason provided for this simplification was that the other factors (multi-path and multi-user interference) are highly dependent on the geometry of the network, and are therefore apparently difficult to predict.

2.2 Allowance for reasonable propagation losses will reduce the minimum separation

When the above assumption about the interference threshold is applied to the analysis of a generic PCS receiver, minimum separation distances between the PCS receiver and UWB devices ranging from about 35 to 100 meters are derived based on a number of different values for receiver noise figure and based on a 1 dB increase in noise figure. In particular, a result of 35 meters is highlighted in an example calculation presented in Table 3.1. More generally, minimum separation ranges of 35 to 100 meters are obtained using a free-space propagation model and about 7 to 12 meters when using a more realistic path loss exponent of n=3.3 in Figure 3.4. These results are obtained under the assumptions that there is no other interference (such as multi-path or multi-user interference) and also that the interference threshold for the PCS receiver is –111 dBm, which is 6 dB below the thermal noise floor. (We will see later that this is not the actual interference threshold found when the lab tests were performed.)

There are a number of reasons why the result of 35 meters in Table 3.1 is too conservative. First, a review of relevant literature indicates that free-space propagation is not typically assumed in such cases. For example, in a study of indoor propagation for RF signals at 910 MHz and 1.75

GHz by Bultitude *et. al.*, the authors indicate that a reasonable value of 12 dB additional loss (relative to free space path loss) due to diffraction or penetration loss is reasonable for 1.75 GHz at a range of 10 m in a typical indoor (office building) environment.[1] Other reports submitted as part of these UWB proceedings have indicated that other factors such as foliage, buildings, and terrain can cause significant losses relative to free-space propagation, and this is even acknowledged by the QUALCOMM comments, so there is no reason to assume a simple free-space model in this case.[2] If we use the 12 dB loss figure given above in the calculations in QUALCOMM 's Table 3.1, then the required path loss is reduced to 52.78 dB and the resulting minimum separation is less than 9 meters.

2.3 Emission limits proposed by the FCC and XtremeSpectrum provide an additional 12 dB of protection margin for PCS frequency band

In order to provide additional protection to systems operating below 2.7 GHz, we have proposed in prior comments that limits on average power for UWB emissions be reduced below Part 15 levels.[3] In the PCS band this reduction would be 12 dB, which is in accordance with the reduction proposed by the FCC in the NPRM. When this reduction in UWB transmit power is also included in the calculations for minimum separation, the required path loss is further reduced to 43.78 dB. (Here we have reduced the correction factor for indoor propagation to only 9 dB due to reduced range.) The resulting separation using reduced emission limits is now approximately 3 meters using the equations in Table 3.1.

It is interesting to note that QUALCOMM in Figure 3.4 also provides a plot showing, for example, that the minimum separation for non-line of sight scenarios (where they assume a propagation loss exponent of n=3.3) is approximately 7 meters using the same values for receiver noise figure and interference threshold as above. If the results in this figure were recomputed using a 12 dB lower level for UWB emission, this separation range would also be reduced accordingly to approximately 3 meters.

Also, we note again that all of the computations above assume that some type of harmful interference would result when UWB emission is still 6 dB below the *thermal noise floor* of the PCS receiver. As we will see in the next section, however, even the laboratory tests indicated that a more accurate interference threshold is 6 to 16 dB higher. If we assume even a 4 dB higher allowable level in our analysis for UWB power at the receiver (i.e. still 2 dB *below* the thermal noise floor), the minimum UWB-PCS separation now becomes less than 2 meters. Of course, such a result is probably beyond the accuracy of this simple model, but the point is that a few more realistic assumptions makes a significant difference in the results.

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[1] Robert J.C. Bultitude, Samy Mahoud and William Sullivan, "A Comparison of Indoor Radio Propagation Characteristics at 910 MHz and 1.75 GHz," IEEE Journal on Selected Areas in Communications, Vol. 7, No. 1, January 1989, p. 20.

[2] Chapter 5 of the NTIA's report 01-43 contained a discussion of many factors that can cause additional propagation losses in real-world environments, including specific adjustment factors that could be used for each effect. QUALCOMM's comments include a term in equation 3-9 to adjust for non-line-of-sight propagation effects, but no value is included in the calculations.

[3] See, for example, XtremeSpectrum's comments for UWB proceedings 98-153 dated March 12, 2001.

2.4 The laboratory interference measurements indicate higher interference thresholds

The report also presents results of testing by QUALCOMM that measured the actual frame error rate (FER) of a PCS handset that was supplied with controlled levels of a PCS signal and UWB interference. The main results of the laboratory tests are presented in Figure 5.1 of the report. In this figure, the results of nine test cases are plotted: three different UWB signals in combination with three different levels of PCS signal strength. These results give us a clear picture of the actual level at which UWB signals begin to produce interference in a PCS receiver.

In the tests, a PCS signal with a fixed power was injected and the UWB interference level was gradually increased while measurements were made of the FER of the receiver. The power level used for the PCS signal was set to several different levels throughout the test and was clearly intended to simulate the normal operating received signal levels for a PCS handset, perhaps even conservative (low) levels. Because of this test set-up, we can use the measured UWB signal levels to determine actual interference threshold levels.

Given this, the plots indicate that the frame error rates as measured in the tests only became non-zero when the UWB interference power exceeded levels of –105 to -95 dBm for the various levels of PCS power. The worst threshold for these cases is still 6 dB higher than the level assumed in the analysis, and the best is a full 16 dB higher. As we saw in the previous section (where a 4 dB higher threshold was analyzed), when levels such as these (-105 to –95 dBm) are used for a more realistic interference threshold, the likelihood of UWB interference becomes remote.

3. Conclusions

After careful examination of the test results and analyses in the QUALCOMM report, it is clear that there no harmful interference in PCS systems will result from UWB operation under Part 15 rules when emissions in the 1.9 GHz PCS band are limited to 12 dB below current Part15 levels. When the analyses of the report are modified to include the 12 db reduced emission limits and more realistic assumptions for propagation losses, the indicated minimum separation distances are significantly reduced. When we further incorporate a more realistic level for PCS receiver interference threshold, which is supported by QUALCOMM's own test results, the conclusion is that there is little likelihood of UWB devices causing any interference to PCS receivers even at close proximity.

Respectfully submitted,

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